# PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

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# PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

| | |
|---|---|
| Date of mailing *(day/month/year)* | 25.10.2004 |
| Applicant's or agent's file reference | **IMPORTANT NOTIFICATION** |
| MJB07237WO | |

| International application No. | International filing date *(day/month/year)* | Priority date *(day/month/year)* |
|---|---|---|
| PCT/GB 03/01943 | 13.05.2003 | 17.06.2002 |

Applicant
CAMBRIDGE POSITIONING SYSTEMS LIMITED et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

The applicant's attention is drawn to Article 33(5), which provides that the criteria of novelty, inventive step and industrial applicability described in Article 33(2) to (4) merely serve the purposes of international preliminary examination and that "any Contracting State may apply additional or different criteria for the purposes of deciding whether, in that State, the claimed inventions is patentable or not" (see also Article 27(5)). Such additional criteria may relate, for example, to exemptions from patentability, requirements for enabling disclosure, clarity and support for the claims.

| Name and mailing address of the international preliminary examining authority: | Authorized Officer |
|---|---|
| European Patent Office<br>D-80298 Munich<br>Tel. +49 89 2399 - 0 Tx: 523656 epmu d<br>Fax: +49 89 2399 - 4465 | Weman, E<br>Tel. +49 89 2399-7961 |

Form PCT/IPEA/416 (January 2004)

# PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

| Applicant's or agent's file reference | FOR FURTHER ACTION | See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416) |
|---|---|---|
| MJB07237WO | | |
| International application No. | International filing date *(day/month/year)* | Priority date *(day/month/year)* |
| PCT/GB 03/01943 | 13.05.2003 | 17.06.2002 |
| International Patent Classification (IPC) or both national classification and IPC | | |
| G01S5/02 | | |
| Applicant | | |
| CAMBRIDGE POSITIONING SYSTEMS LIMITED et al. | | |

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 18 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the opinion
   - II ☐ Priority
   - III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☐ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

| Date of submission of the demand | Date of completion of this report |
|---|---|
| 16.01.2004 | 25.10.2004 |
| Name and mailing address of the international preliminary examining authority: | Authorized Officer |
| European Patent Office<br>D-80298 Munich<br>Tel. +49 89 2399 - 0 Tx: 523656 epmu d<br>Fax: +49 89 2399 - 4465 | Ó Donnabháin, C<br>Telephone No. +49 89 2399-7134 |

# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB 03/01943

## I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

**Description, Pages**

1-21 as originally filed

**Claims, Numbers**

1-33 as originally filed

**Drawings, Sheets**

1/7-7/7 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☒ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

   *(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*

   **see separate sheet**

6. Additional observations, if necessary:

**III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability**

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

   ☐ the entire international application,

   ☒ claims Nos. 1-33

   because:

   ☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (specify):

   ☒ the description, claims or drawings *(indicate particular elements below)* or said claims Nos. 1-33 are so unclear that no meaningful opinion could be formed *(specify)*:

   **see separate sheet**

   ☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

   ☒ no international search report has been established for the said claims Nos. 1-33

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

   ☐ the written form has not been furnished or does not comply with the Standard.

   ☐ the computer readable form has not been furnished or does not comply with the Standard.

**Re Item I**

**Basis of the Opinion**

**Extension Beyond the Disclosure of the Application as Filed (Art 34(2)(b) PCT).**

It would appear that the amendments carried out to the claims (and subsequently pages 8-15a of the description) extend the subject-matter of the application beyond that of the original disclosure. This can be clearly seen in claim 1, as following:

Interpreting the steps of method claim 1 in the light of the description (pages 16-20):

the section created from step (a) appears to be r(t) - (page 17, line 3)
the sections referred to in step (b) appear to be Sa(t), Sb(t), Sc(t) - (page 17, line 3)
the first function in step (c) appears to be a(t) - (page 18, line 11)
the blurred terminal estimate of (c) is b(t) - (page 18, line 31)
the second function in step (d) appears to be a(t) - (page 18, line 11)
the blurred terminal section of (d) appears to be a(t)*r(t) **not r(t)*pa(t) of page 19, line 3.**

Thus, it would appear that the amendments to the claims, filed with the letter of the applicant of August 11 2004, go beyond the content of the application as originally filed.

The amendments to the description, filed with the letter of the applicant dated August 11 2004, were intended to bring the description into accordance with the claims. However, as the amendments to the claims were deemed inadmissible, the subsequent amendments to the text of the description was deemed also inadmissible.

Subject to the conditions of Rule 70.2(c), the international Report is based on the application documents as originally filed.

**Re Item III**

**Non-establishment of opinion with regard to novelty, inventive step and industrial applicability**

**1 Clarity (Art. 6 PCT)**

The claims do not fulfill the requirements of Art. 6 PCT as they lack conciseness, clarity.

1.1 The claims lack conciseness as required under Art. 6 PCT: independent method claims 1 and 9 and apparatus claims 23-30, although drafted as separate independent claims, relate effectively to the same subject-matter, thus lacking conciseness. Moreover, lack of clarity of the claims as a whole arises, since the plurality of independent claims makes it difficult, if not impossible, to determine the matter for which protection is sought, and places and undue burden on others seeking to establish the extent of protection.

1.2 Due to the vague and imprecise wording of the independent claims, a lack of clarity and conciseness within the meaning of Article 6 PCT arose to such an extent as to have rendered a meaningful search of the claims impossible. Terms such as "blurred estimate", "Blurred terminal section" etc. do not form part of the terminology used in the relevant field of invention. Moreover, definition of the terms "blurred estimate", "Blurred terminal section" cannot be divined with any certainty from the description. Thus, these terms are vague and unclear, leaving the reader in doubt as to the meaning of the technical features to which they refer. Comparison between the description on pages 16-20 and the claims leads to the conclusion that the broad scope of what is claimed is not commensurate with the disclosure.

The individual steps of the methods of claims 1 and 9 are unclear. Consider, for example step (c) of claim 1:

> (c) calculating a blurred estimate of the signal received at the terminal from the first transmitter using a first function dependent on the first section and the section created at the terminal in step (a)

The method of calculating the blurred estimate is considered ambiguous. It is not clear whether the blurred estimate is calculated using *a first function* and *the section created at the terminal in step (a);* or whether the blurred estimate is calculated using the *first function* is based on *the section created at the terminal in step (a);*

1.3 Independent claims 9, 23-30 lack clarity. In claims 9, 23-30, the terms "terminal section", etc. appearing in brackets are employed as antecedent definition for later use of these terms in the claim. However, this introduces lack of clarity, as expressions between parentheses are intended as reference signs for drawing and are thus, not considered as features of a claim.

1.4 Thus, given the present objections to lack of clarity of the claims, and subsequent to the conditions of Art. 34(4)(a) PCT, it is not possible to provide an opinion as to novelty, inventive step and industrial applicability (Art. 33(1) PCT).

## 2 Further Defects of the Application

2.1 The claims have not been drafted in the "two-part form" as required under Rule 6.3(b) PCT.

2.2 The claims lack reference signs to facilitate quicker understanding, according to Rule 6.2(a) PCT.

## 3 Comments

Although the claims fail to satisfy the requirements of the PCT to such an extent that meaning examination is not possible, the following comments are added:

The teaching of the application, as elucidated by the progression of formulae from page 17 to the beginning of page 19, appears to contain inventive information. A positioning method employing a subtractive interference cancellation like algorithm, which takes account of channel behaviour but without explicit knowledge of same (ala page 17-19 of the description) is neither disclosed nor rendered obvious by the prior art on file.

peaks are used to estimate the time offsets of the corresponding signals, giving sufficient independent timing measurements (three in this case) to compute a position fix.

If the peak 601 corresponding to the signals from Node B 203 is too weak to be resolved, a further iteration could be undertaken in which the signals from Node B 202 could be subtracted to yield a second residual signal (Figure 7). There is a clear correlation peak 701 at a delay of approximately 7 chips as expected.

WO-A-0055992 describes a synchronisation and cell search method for a terminal in a mobile telephone system, which uses an estimate of the communication channel (see Figure 4) to construct an estimate of a known synchronisation signal and correlates this with the received signal in order to allow cell identification.

In the prior art method of EP 01306115.5 discussed above, the assumption is made that the signal received at the terminal is a simple sum of the transmitted signals attenuated, phase rotated and delayed by the individual path lengths between transmitter and receiver. In a more complex system in which the transmission channel has incorporated non-linear effects, multi-path and noise, the transmitted signal is further degraded by these effects making the edges of the waveform less clearly defined in time. This process we have called a 'blurring' of the signal. When attempting to cancel a blurred signal, the process of subtracting only a simply scaled, delayed and phase rotated copy of the signal recorded by one sampling device from the signal received at the terminal may not remove the contribution from the transmitter associated with the one sampling device accurately enough. The present invention therefore provides improved methods which remove more accurately the contribution of the signals from the transmitter associated with the one sampling device from the signals received at the terminal by creating an equivalently 'blurred' estimate of the signal recorded at the terminal.

This process requires the creation of short sections of the recorded and sampled baseband representations of the signal to be used in the method. We have called such a section of data 'a section of the representation of the signal' in the following description.

A first aspect of the invention therefore provides a method of finding the time offset between signals transmitted by at least one of a plurality of transmitters of a

communications network and received by a receiver attached to a terminal, the method comprising the steps of

(a) creating at the terminal a section of a representation of the signals from the transmitters received by the receiver;

(b) creating a first section of a representation of the signal transmitted by a first of said transmitters, and creating a second section of a representation of the signal transmitted by a second of said transmitters, each of which sections overlaps in time with the section created at the terminal;

(c) creating a first function dependent on the first section and the section created at the terminal in step (a), and convolving the first section with the first function to form a blurred estimate of the signal received at the terminal from the first transmitter;

(d) creating a second function dependent on the first section and the section created at the terminal in step (a), and convolving the terminal section with the second function to form a blurred terminal section;

(e) subtracting the blurred estimate from the blurred terminal section to produce a blurred residual representation; and

(f) estimating the time offset between the blurred residual representation and the second section.

Preferably, the first function, which is used to create the blurred estimate, is a convolution of the first section of a representation of the signal transmitted by a first of said transmitters (the 'first section') with a cross-correlation of the section of a representation of the signals from the transmitters received by the receiver (the 'terminal section') and the first section. The above cross-correlation is preferably a windowed cross-correlation created by enhancing the significant components of the cross-correlation function.

Similarly, the second function, which is used to create the blurred terminal section, is a convolution of the terminal section with the auto-correlation profile of the first section.

Preferably, the blurred residual representation is cross-correlated with the second section of a representation of the signal transmitted by a second of said transmitters (the 'second section') to estimate the time offset.

Preferably, the first and second sections are created at the respective first and second transmitters, but they may be created elsewhere. They may be created in one or more sampling devices attached to the respective transmitters or located elsewhere, or they may be created by computer programs running anywhere in the communications network, or elsewhere, using information supplied from the network about the transmitted signals.

The various signal representation sections may be sent to one or more computing devices in which said estimates and time offsets, and a terminal location estimate, may be calculated. In some embodiments, the time offset between said section of a representation of the signals received by the receiver and said first section may first be calculated, and may then be used in the calculation of said terminal location estimate. The time offset between said section of a representation of the signals received by the receiver and said first section may be calculated using said sections or it may be calculated by other means, for example by calculating the time offset of a known component of the signal such as a pilot code. The time offset between said blurred residual representation and said second section may be calculated using said second section or it may be calculated by other means, for example by using a known component of the signal such as a pilot code.

The present invention thus overcomes the hearability problem by, for example, using a separate sampling device for each transmitter which sends to a computing device a representation of the signals transmitted only by that transmitter, by performing a cross-correlation of the representation sent back by the mobile terminal with the representation sent back by the sampling device associated with one of the transmitters to estimate the time offset between them, and by subtracting a blurred estimate of that signal from a blurred representation sent back by the mobile terminal, in order to reduce its effect on the remaining signals as far as possible. The cross-correlation and blurred subtraction steps may be iterated until no useful signals remain to be extracted. Simulations show that this provides a greater hearability gain than the straight subtraction method of the prior art of EP 01306115.5 while maintaining the advantages over IP-DL.

In some systems, the hearability problem may be solved simply by subtracting a blurred estimate of the signals received from just one transmitter, usually the brightest, from a blurred representation of the signals received at the terminal leaving a blurred residual representation in which the time offsets of the pilot codes, blurred

pilot codes or any other known portions of the transmitted signals, may be determined.

Thus a second aspect of the invention therefore provides a method of finding the time offset relative to a reference within the terminal of a component of a signal transmitted by one of a plurality of transmitters of a communications network and received by a receiver attached to a terminal, the method comprising the steps of

(a) creating at the terminal a section of a representation of the signals from the transmitters received by the receiver (a "terminal section");

(b) creating a section of a representation of the signal transmitted by another transmitter (a "transmitter section"), which section overlaps in time with the section created at the terminal;

(c) creating a first function dependent on the terminal section and the transmitter section created in steps (a) and (b), and convolving the terminal section with the first function to form a blurred estimate of the signal received at the terminal from the other transmitter;

(d) creating a second function dependent on the terminal section and the transmitter section created in steps (a) and (b), and convolving the terminal section with the second function to form a blurred terminal section;

(e) subtracting the blurred estimate from the blurred terminal section to produce a blurred residual representation; and

(f) estimating the time offset between the blurred residual representation and the signal component.

Preferably, the first function, which is used to create the blurred estimate, is a convolution of the transmitter section with a cross-correlation of the terminal section and the transmitter section. This cross-correlation is preferably a windowed cross-correlation created by enhancing the significant components of the cross-correlation function.

Similarly, the second function, which is used to create the blurred terminal section, is a convolution of the terminal section with the auto-correlation profile of the transmitter section.

The known components of the transmitted signals in the second aspect of the invention may, for example, be the pilot codes. Before the time offset is estimated the known signal components may be blurred by convolution with another function.

In both the first and the second aspects of the invention, the section of the representation of the signals received by the receiver at the terminal may be recorded in the terminal before being sent to a computing device. Alternatively, the section may be transferred in real time to the computing device and a recording made there.

Preferably, the section of the representation of the signals transmitted by a transmitter is created at that transmitter, but it may be created elsewhere. It may be created in a sampling device attached to the transmitter or located elsewhere, or it may be created by a computer program running anywhere in the communications network, or elsewhere, using information supplied from the network about the transmitted signals. The calculations may be carried out in a computing device which may be in the handset or elsewhere, for example, a processor connected to the network.

The terminal may be a part of a positioning system, for example as described in any of EP-A-0767594, WO-A-9730360, AU-B-716647 EP-B-0303371, US-A-6094168 and EP-A-1025453 and may be a fixed device associated with a transmitter (for example, the 'fixed receiver' or 'Location Measurement Unit, LMU'), whose purpose is to receive signals from distant transmitters as well as from its associated transmitter, in which case the method of the invention includes the estimation of and subtraction of the signals from its associated transmitter in order to allow it to measure the time offsets of the signals received from distant transmitters.

The representation of the signals received by the receiver attached to the terminal may be a digitised version of the received signals converted first to baseband in the receiver. The representation of the signals transmitted by a transmitter may be a digitised version of the transmitted signals converted first to baseband.

In order to ensure an overlap of the respective sections, a suitably chosen component of the transmitted signals may be used to indicate the start of sampling.

The invention also includes apparatus including a processing means arranged to carry out the method of the first or second aspects of the invention described above.

The apparatus for carrying out the first aspect of the invention may comprise

(a) processing means arranged to create at the terminal a section of a representation of the signals from the transmitters received by the receiver;

(b) processing means arranged to create a first section of a representation of the signal transmitted by a first of said transmitters, and to create a second section of a representation of the signal transmitted by a second of said transmitters, each of which sections overlaps in time with the section created at the terminal;

(c) processing means arranged to create a first function dependent on the first section and the section created at the terminal in step (a), and convolve the first section with the first function to form a blurred estimate of the signal received at the terminal from the first transmitter;

(d) processing means arranged to create a second function dependent on the first section and the section created at the terminal in step (a), and convolve the terminal section with the second function to form a blurred terminal section;

(e) processing means arranged to subtract the blurred estimate from the blurred terminal section to produce a blurred residual representation; and

(f) processing means arranged to estimate the time offset between the blurred residual representation and the second section.

The apparatus for carrying out the second aspect of the invention, for finding the time offset relative to a reference within the terminal of a component of a signal transmitted by one of a plurality of transmitters of a communications network and received by a receiver attached to a terminal, may comprise

(a) processing means arranged to create at the terminal a section of a representation of the signals from the transmitters received by the receiver (a "terminal section");

(b) processing means arranged to create a section of a representation of the signal transmitted by an other transmitter (a "transmitter section");

(c) processing means arranged to create a first function dependent on the terminal section and the transmitter section created in steps (a) and (b), and convolve the terminal section with the first function to form a blurred estimate of the signal received at the terminal from the other transmitter;

(d) processing means arranged to create a second function dependent on the terminal section and the transmitter section created in steps (a) and (b), and convolve the terminal section with the second function to form a blurred terminal section;

(e) processing means arranged to subtract the blurred estimate from the blurred terminal section to produce a blurred residual representation; and

(f) processing means arranged to estimate the time offset between the blurred residual representation and the signal component.

The apparatus may be disposed in a handset or other terminal of a telecommunications network.

The invention also includes a communications network for carrying out the first aspect of the invention, the network comprising

(a) a computing device or devices;

(b) a terminal having a radio receiver attached to the terminal, means for creating a section of a representation of the signals, received by the radio receiver, from the transmitters of the communications network, and means for sending the section to the computing device or devices;

(c) sampling devices associated with respective first and second of said transmitters for creating respective first and second sections of representations of the signal transmitted by the respective transmitter which overlap in time with the section created at the terminal, and for sending the sections of the representations created at said transmitters to said computing device or devices;

the computing device or devices being adapted to perform

1 creation of a first function dependent on the first section and the section created at the terminal, and a convolution of the first section with the first function to provide a blurred estimate of the signal received at the terminal from the first transmitter;

2 creation of a second function dependent on the first section and the section created at the terminal, and a convolution of the section created at the terminal with the second function to provide a blurred terminal section;

3 a subtraction of said blurred estimate from the blurred terminal section to produce a blurred residual representation;

4 a calculation of the time offset between the blurred residual representation and said second section.

A calculation of the position of the terminal may be made using said time offset.

The invention also includes a communications network for carrying out the second aspect of the invention, for finding the time offset relative to a reference within the terminal of a component of a signal transmitted by one of a plurality of transmitters of a communications network and received by a receiver attached to a terminal, the network comprising

(a) a computing device or devices;

(b) a terminal having a radio receiver attached to the terminal, means for creating a section of a representation of the signals, received by the radio receiver, from the transmitters of the communications network (a "terminal section"), and means for sending the section to the computing device or devices;

(c) a sampling device associated with an other transmitter for creating a section of a representation of the signal transmitted by the other transmitter (a "transmitter section") which overlaps in time with the section created at the terminal, and for sending the section of the representations created at the other transmitter to said computing device or devices;

the computing device or devices being adapted to perform

1 creation of a first function dependent on the transmitter section and the terminal section, and a convolution of the transmitter section with the first function to provide a blurred estimate of the signal received at the terminal from the other transmitter;

2 creation of a second function dependent on the transmitter section and the terminal section, and a convolution of the terminal section with the second function to provide a blurred terminal section;

3 a subtraction of said blurred estimate from the blurred terminal section to produce a blurred residual representation;

4 a calculation of the time offset between the blurred residual representation and the signal component.

A calculation of the position of the terminal may be made using said time offset.

The E-OTD positioning systems described generally above work with unsynchronised networks, i.e. any common component of the signals transmitted by any one transmitter is not synchronised in time with the transmission of that component by any other of the transmitters, but instead is transmitted after an unknown time delay, sometimes called the Relative Transmission Delay (RTD). The position calculation requires that this delay is known, and so the positioning systems employ fixed receivers at known locations throughout the network which are set up to measure the transmitted signals and compute the RTDs. It has been described above how the hearability problem hinders the straightforward application of the E-OTD techniques to direct-sequence CDMA systems. However, the second aspect of the present invention overcomes the hearability problem by allowing the very strong signals from a local transmitter to be subtracted from the signals received by the fixed receiver, thus allowing the much weaker signals from the distant transmitters to be measured.

The method of application of E-OTD to CDMA systems then follows that described, for example, in our EP-A-1025453.

The invention also includes one or more computing devices in which the calculations described herein above are made.

The means for carrying out the calculations in the computing device or devices may be components of hardware and/or software.

Therefore, the invention includes a computer program or programs having computer program code means for carrying out the steps performed in the computing device or devices as described above.

## CLAIMS

1. A method of finding the time offset between signals transmitted by at least one of a plurality of transmitters of a communications network and received by a receiver attached to a terminal, the method comprising the steps of

(a) creating at the terminal a section of a representation of the signals from the transmitters received by the receiver;

(b) creating a first section of a representation of the signal transmitted by a first of said transmitters, and creating a second section of a representation of the signal transmitted by a second of said transmitters, each of which sections overlaps in time with the section created at the terminal;

(c) creating a first function dependent on the first section and the section created at the terminal in step (a), and convolving the first section with the first function to form a blurred estimate of the signal received at the terminal from the first transmitter;

(d) creating a second function dependent on the first section and the section created at the terminal in step (a), and convolving the terminal section with the second function to form a blurred terminal section;

(e) subtracting the blurred estimate from the blurred terminal section to produce a blurred residual representation; and

(f) estimating the time offset between the blurred residual representation and the second section.

2. A method according to claim 1, wherein the first function, which is used to create the blurred estimate, is a convolution of the first section of a representation of the signal transmitted by a first of said transmitters (the 'first section') with a cross-correlation of the section of a representation of the signals from the transmitters received by the receiver (the 'terminal section') and the first section.

3. A method according to claim 2, wherein the cross-correlation is a windowed cross-correlation created by enhancing the significant components of the cross-correlation function.

4. A method according to any of claims 1 to 3, wherein the second function, which is used to create the blurred terminal section, is a convolution of the terminal section with the auto-correlation profile of the first section.

5. A method according to ~~any of~~ claims 1 ~~to~~ 4, wherein the blurred residual representation is cross-correlated with the second section of a representation of the signal transmitted by a second of said transmitters (the 'second section') to estimate the time offset.

6. A method according to ~~any of~~ claims 1 ~~to~~ 5, wherein the first and second sections are created at the respective first and second transmitters.

7. A method according to ~~any of~~ claims 1 ~~to~~ 5, wherein the first and second sections are created in one or more sampling devices attached to the respective transmitters or located elsewhere.

8. A method according to ~~any of~~ claims 1 ~~to~~ 5, wherein the first and second sections are created by computer programs running anywhere in the communications network, or elsewhere, using information supplied from the network about the transmitted signals.

9. A method of finding the time offset relative to a reference within the terminal of a component of a signal transmitted by one of a plurality of transmitters of a communications network and received by a receiver attached to a terminal, the method comprising the steps of

(a) creating at the terminal a section of a representation of the signals from the transmitters received by the receiver (a "terminal section");

(b) creating a section of a representation of the signal transmitted by an other transmitter (a "transmitter section"), which section overlaps in time with the section created at the terminal;

(c) creating a first function dependent on the terminal section and the transmitter section created in steps (a) and (b), and convolving the terminal section with the first function to form a blurred estimate of the signal received at the terminal from the other transmitter;

(d) creating a second function dependent on the terminal section and the transmitter section created in steps (a) and (b), and convolving the terminal section with the second function to form a blurred terminal section;

(e) subtracting the blurred estimate from the blurred terminal section to produce a blurred residual representation; and

(f) estimating the time offset between the blurred residual representation and the signal component.

10. A method according to claim 9, wherein the first function, which is used to create the blurred estimate, is a convolution of the transmitter section with a cross-correlation of the terminal section and the transmitter section.

11. A method according to claim 10, wherein the cross-correlation is a windowed cross-correlation created by enhancing the significant components of the cross-correlation function.

12. A method according to any of claims 9 to 11, wherein the second function, which is used to create the blurred terminal section, is a convolution of the terminal section with the auto-correlation profile of the transmitter section.

13. A method according to ~~any of~~ claims 9 to 12, wherein the known components of the transmitted signals in the second aspect of the invention are pilot codes.

14. A method according to any of claims 9 to 13, wherein, before the time offset is estimated, the known signal components are blurred by convolution with another function.

15. A method according to any of claims 9 to 14, wherein the section of the representation of the signals transmitted by a transmitter is created at that transmitter.

16. A method according to any of claims 9 to 14, wherein the section of the representation of the signals transmitted by a transmitter is created in one or more sampling devices attached to the respective transmitters or located elsewhere.

17. A method according to any of claims 9 to 14, wherein the section of the representation of the signals transmitted by a transmitter is created by a computer program running anywhere in the communications network, or elsewhere, using information supplied from the network about the transmitted signals.

18. A method according to any of claims 1 to 14, wherein the section of the representation of the signals received by the receiver at the terminal is recorded in the terminal before being sent to a computing device.

19. A method according to any of claims 1 to 14, wherein the section of the representation of the signals received by the receiver at the terminal is transferred in real time to the computing device and a recording made there.

20. A method according to any of claims 1 to 19, wherein the representation of the signals received by the receiver attached to the terminal may be a digitised version of the received signals converted first to baseband in the receiver.

21. A method according to any of claims 1 to 20, wherein the representation of the signals transmitted by a transmitter may be a digitised version of the transmitted signals converted first to baseband.

22. Apparatus including a processing means arranged to carry out the method of any of claims 1 to 21.

delete like 23 (1) ? also dep like 2-8 ? also 24 (9) dep like 10 - ?

23. Apparatus for finding the time offset between signals transmitted by at least one of a plurality of transmitters of a communications network and received by a receiver attached to a terminal, the apparatus comprising

(a) processing means arranged to create at the terminal a section of a representation of the signals from the transmitters received by the receiver;

(b) processing means arranged to create a first section of a representation of the signal transmitted by a first of said transmitters, and to create a second section of a representation of the signal transmitted by a second of said transmitters, each of which sections overlaps in time with the section created at the terminal;

(c) processing means arranged to create a first function dependent on the first section and the section created at the terminal in step (a), and convolve the first section with the first function to form a blurred estimate of the signal received at the terminal from the first transmitter;

(d) processing means arranged to create a second function dependent on the first section and the section created at the terminal in step (a), and convolve the terminal section with the second function to form a blurred terminal section;

(e) processing means arranged to subtract the blurred estimate from the blurred terminal section to produce a blurred residual representation; and

(f) processing means arranged to estimate the time offset between the blurred residual representation and the second section.

24. Apparatus for finding the time offset relative to a reference within the terminal of a component of a signal transmitted by one of a plurality of transmitters of a communications network and received by a receiver attached to a terminal, the apparatus comprising

(a) processing means arranged to create at the terminal a section of a representation of the signals from the transmitters received by the receiver (a "terminal section");

(b) processing means arranged to create a section of a representation of the signal transmitted by an other transmitter (a "transmitter section");

(c) processing means arranged to create a first function dependent on the terminal section and the transmitter section created in steps (a) and (b), and convolve the terminal section with the first function to form a blurred estimate of the signal received at the terminal from the other transmitter;

(d) processing means arranged to create a second function dependent on the terminal section and the transmitter section created in steps (a) and (b), and convolve the terminal section with the second function to form a blurred terminal section;

(e) processing means arranged to subtract the blurred estimate from the blurred terminal section to produce a blurred residual representation; and

(f) processing means arranged to estimate the time offset between the blurred residual representation and the signal component.

25. A telecommunications terminal including apparatus for finding the time offset between signals transmitted by at least one of a plurality of transmitters of a communications network and received by a receiver attached to a terminal, the apparatus comprising

(a) processing means arranged to create at the terminal a section of a representation of the signals from the transmitters received by the receiver;

(b) processing means arranged to create a first function dependent on a first section of a representation of the signal transmitted by a first of said transmitters which overlaps in time with the section created at the terminal and which is sent to the terminal and the section created at the terminal in step (a), and convolve the first section with the first function to form a blurred estimate of the signal received at the terminal from the first transmitter ;

(c) processing means arranged to create a second function dependent on the first section and the section created at the terminal in step (a), and convolve the section created at the terminal with the second function to form a blurred terminal section;

(d) processing means arranged to subtract the blurred estimate from the blurred terminal section to produce a blurred residual representation; and

(e) processing means arranged to estimate the time offset between the blurred residual representation and a second section of a representation of the signal transmitted by a second of said transmitters which overlaps in time with the section created at the terminal and which is sent to the terminal.

26. A telecommunications terminal including apparatus for finding the time offset relative to a reference within the terminal of a component of a signal transmitted by one of a plurality of transmitters of a communications network and received by a receiver attached to a terminal, the apparatus comprising

(a) processing means arranged to create at the terminal a section of a representation of the signals from the transmitters received by the receiver (a "terminal section");

(b) processing means arranged to create a first function dependent on the terminal section and a section of a representation of the signal transmitted by another transmitter (a "transmitter section") which is sent to the terminal, and convolve the terminal section with the first function to form a blurred estimate of the signal received at the terminal from theother transmitter;

(c) processing means arranged to create a second function dependent on the transmitter section and the terminal section created at the terminal, and convolve the terminal section with the second function to form a blurred terminal section;

(d) processing means arranged to subtract the blurred estimate from the blurred terminal section to produce a blurred residual representation; and

(e) processing means arranged to estimate the time offset between the blurred residual representation and the signal component.

27. A communications network for finding the time offset between signals transmitted by at least one of a plurality of transmitters of a communications network and received by a receiver attached to a terminal, the network comprising

(a) a computing device or devices;

(b) a terminal having a radio receiver attached to the terminal, means for creating a section of a representation of the signals, received by the radio receiver, from the transmitters of the communications network, and means for sending the section to the computing device or devices;

(c) sampling devices associated with respective first and second of said transmitters for creating respective first and second sections of

representations of the signal transmitted by the respective transmitter which overlap in time with the section created at the terminal, and for sending the sections of the representations created at said transmitters to said computing device or devices;

the computing device or devices being adapted to perform

1 creation of a first function dependent on the first section and the section created at the terminal, and a convolution of the first section with the first function to provide a blurred estimate of the signal received at the terminal from the first transmitter;

2 creation of a second function dependent on the first section and the section created at the terminal, and a convolution of the section created at the terminal with the second function to provide a blurred terminal section;

3 a subtraction of said blurred estimate from the blurred terminal section to produce a blurred residual representation;

4 a calculation of the time offset between the blurred residual representation and said second section.

28. A communications network for finding the time offset relative to a reference within the terminal of a component of a signal transmitted by one of a plurality of transmitters of a communications network and received by a receiver attached to a terminal, the network comprising

(a) a computing device or devices;

(b) a terminal having a radio receiver attached to the terminal, means for creating a section of a representation of the signals, received by the radio receiver, from the transmitters of the communications network (a "terminal section"), and means for sending the section to the computing device or devices;

(c) a sampling device associated with an other transmitter for creating a section of a representation of the signal transmitted by the other transmitter (a "transmitter section") which overlaps in time with the section created at the terminal, and for sending the section of the representations created at the other transmitter to said computing device or devices;

the computing device or devices being adapted to perform

1 creation of a first function dependent on the transmitter section and the terminal section, and a convolution of the transmitter section with the first function to provide a blurred estimate of the signal received at the terminal from the other transmitter;

2 creation of a second function dependent on the transmitter section and the terminal section, and a convolution of the terminal section with the second function to provide a blurred terminal section;

3 a subtraction of said blurred estimate from the blurred terminal section to produce a blurred residual representation;

4 a calculation of the time offset between the blurred residual representation and the signal component.

29. A computing device or devices for use in a communications network comprising a terminal having a radio receiver attached to the terminal, means for creating a section of a representation of the signals, received by the radio receiver, from the transmitters of the communications network, and means for sending the section to the computing device or devices; and sampling devices associated with respective first and second of said transmitters for creating respective first and second sections of representations of the signal transmitted by the respective transmitter which overlap in time with the section created at the terminal, and for sending the sections of the representations created at said transmitters to said computing device or devices,

the computing device or devices being adapted to perform

1 creation of a first function dependent on the first section and the section created at the terminal, and a convolution of the first section with the first function to provide a blurred estimate of the signal received at the terminal from the first transmitter;

2 creation of a second function dependent on the first section and the section created at the terminal, and a convolution of the section created at the terminal with the second function to provide a blurred terminal section;

3 a subtraction of said blurred estimate from the blurred terminal section to produce a blurred residual representation;

4 a calculation of the time offset between the blurred residual representation and said second section.

30. A computing device or devices for use in a communications network comprising a terminal having a radio receiver attached to the terminal, means for creating a section of a representation of the signals, received by the radio receiver, from the transmitters of the communications network (a "terminal section"), and means for sending the section to the computing device or devices; and a sampling device associated with an other transmitter for creating a section of a representation

of the signal transmitted by the other transmitter (a "transmitter section") which overlaps in time with the section created at the terminal, and for sending the section of the representations created at the other transmitter to said computing device or devices,

the computing device or devices being adapted to perform

1 creation of a first function dependent on the transmitter section and the terminal section, and a convolution of the transmitter section with the first function to provide a blurred estimate of the signal received at the terminal from the other transmitter;

2 creation of a second function dependent on the transmitter section and the terminal section, and a convolution of the terminal section with the second function to provide a blurred terminal section;

3 a subtraction of said blurred estimate from the blurred terminal section to produce a blurred residual representation;

4 a calculation of the time offset between the blurred residual representation and the signal component.

31. A computer program or programs comprising computer program code means adapted to perform the steps of the computing device of claim 29.

add steps

32. A computer program or programs comprising computer program code means adapted to perform the steps of the computing device of claim 30.

add steps

33. A method of calculating the position of a mobile terminal in a communications network which includes the method of any of claims 1 to 21.

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